Annotated Bibliography


Studies that examine the effects of trampling in tropical rain forests are rare. Three trails with varying periods of human use and recovery in the Cost Rican rainforest were the study sites. A curvilinear relationship was found between human impacts on trailside plants, which are similar to findings of research done in mid-latitudes. The recovery period of two years and eight months occurred rapidly. Herbs and seedlings happened to be more abundant in trampled zones that in untrampled areas. This was due to more sunlight reaching the forest surface due to the existence of the trail. Shifting trails throughout tropical environments was the best management strategy.


The demographic information provided by Chavez is widely cited in many perception studies about mountain biking. The only portion that was used in the research concerned the general characteristics of mountain bikers. This literature includes the trail types and conditions that mountain bikers prefer when they choose the trails that they will be riding. In general, most mountain bikers are from the ages of 28 to 32, white and male. Singletrack trails are what many cyclists prefer to ride.


Vegetation in the Eagle Cap Wilderness Area in northeastern Oregon has been altered by the construction of trails, campsites and fire suppressions techniques. The amount and type of changes varied between vegetation types and with the differences in activity. Densely forested areas tended to have localized changes that resulted intensive recreational activities. The lack of ecological information and complications of implementing regulations impeded the minimization of these changes. Further management suggestions were provided.


Geographers have done much work concerning the topic of recreational ecology, and how it affects the environment. Cole acknowledges that a unique geographic perspective is absent concerning this topic. Further work is open to a geographic perspective because recreational impact is still very rudimentary. Geographic methods are useful in three areas: 1. understanding the spatial variability of site susceptibility, 2. analyzing spatial distributions of impact, and 3. integrating social ecological concerns in the development of management programs.

Ibid. 1987. “Effects of Three Seasons of Experimental Trampling on Five Montane Forest Communities and Grassland in Western Montana, USA.” Biological Conservation. 40: 219-244.

Six vegetation types, one grassland and five forest communities, were experimentally trampled for three successive summers. A strong curvilinear relationship could be made between the amount of trampling and vegetation cover loss, species loss and an increase in penetration resistance. A linear relationship between the amount of trampling and an increase in mineral soil exposure was determined from the research. The relative vulnerability of each vegetation type was considered along with the number of years of trampling required before damage leveled off.


Various recreational activities have an effect on the impacts associated with trampling. The goal of this work involved the impact on vegetation and groundcover conditions that result hikers horses and llamas. After every test trampling impacts were applied. Llamas were found to create minimal amounts of damage. Higher frequencies of trampling caused high levels of damage, but a relationship between trampling intensity and disturbance intensity was non-linear.


Studying the individual processes operating on footpaths is covered using three methods that are simple and easy. These methods are used for studying the erosional impacts of trails on a large scale. The generalized information is valuable because correlations between different factors can be made and further studies may gathered from the
general data that is gathered. Three methods of measurement were considered in this research paper. All of them each correspond to a three different time scales. Aerial photography may be used to illustrate changes over a long-term, and has proved sufficient for distinguishing between path sections with differing resistance to erosion. Two methods are reviewed for short-term measurements of fixed positions. Simple techniques used for a large number of different types of sites may be more effective than detailed measurements at a few sites.

This article presented the possibility of making a correlation between the occurrence of a common species, the impact of intense trampling and the soil quality for a given area. Trampling is correlated with the density of the soil, the resistance of the soil to water penetration, water content, and the height of the trail above the water table. The results of the survey illustrated that the soil located in the tread of the trail holds less water than the soil located off the trail. The vegetation near the study trail was resistant to trampling suggesting the some species are more suited for resistance. Grasslands provide suitable areas for the construction of trails.

Intensive recreational activities alter soil properties. Mountain environments are sensitive and recreational use must be monitored diligently in order to prevent problems associated with erosion. Thirty-nine sites, all campgrounds, were the test sites where soil compaction, soil moisture and soil organic matter were the focus. Utilizing the relationships between soil factors as well as soil/plant and light/plant relationships in conjunction with a soil/vegetation survey, the development of general rules can be accomplished for locating, developing, maintaining and rehabilitating high use recreational areas.

Trail research conducted in the Drakensberg Mountains, South Africa provided guidelines for the synthesis of a technique that enables assessment of path erosion risk before paths are planned and constructed. The application of this tool is used for proper alignment of trails in areas that may limit the amount of erosion to a trail. It can aid in the selection of low-maintenance routes and help in preparing and anticipating maintenance budgets.

Sixty-three wilderness area land managers were surveyed in order to obtain their views concerning the most common types of problems associated with these unique areas. The Wilderness Act of 1964 prohibits any type of motorized vehicles or equipments from being used in designated wilderness areas. Site deterioration was the most common problem. The degree of deterioration varied from site to site.

The objective of the study was to determine vegetation changes occurring along trails in an eastern ecosystem supporting second-growth deciduous forest. Studies performed at the Shenandoah National Park in Virginia, using ten trails, demonstrated that cover and species diversity increased toward the trail in eight out of ten cases. Competition for light and resistance to trampling were thought to influence the occurrence of plants along the transects. Vegetation along the trail displayed patterns of low-growth, early blooming or graminoid characteristics and hemicyryptophyte, therophyte or chamaephyte life forms. Flora found in areas that were undisturbed tended to follow patterns of scattered cover and frequency, woody growth forms or delicate herbaceous forms and phanerophyte or geophyte life forms.

Jacobsen, Jim, Trail coordinator for Camp Tamarancho. Interview by author, 6 December 2000, Fairfax. Personal interview. San Francisco State University, San Francisco.
The Jim Jacobsen interview was conducted to find out more about switch back turns and climbing turns. The differences between the two are important for design purposes, proper construction, site appropriateness for the two types of turns, and general maintenance guidelines. Jacobsen’s knowledge of trail designs specific to mountain biking provides a foundation for many land managers to follow. Trail conflict issues were discussed as reasons for specific designs to minimize the problem.

This study considered two locational variables: vegetation type and slope gradient in order examine the potential for soil due to erosion on new trails. Alpine areas are delicate and the existence of a trail can be detrimental to this type of environment. Vegetation explained very little variance in soil loss. Slope gradient and vegetation type explained 34.3% variance. The presence of permafrost contributed to soil loss because the soil subsided once the melting occurred.


The soil survey described the main type of substrate found in the proposed study area. Saurin and Bonnydoon, both types of clay soils are found at Camp Tamarancho in Fairfax, California. Both of these types of soil are prone high rates of water erosion.


Two types of hiking boots were compared in order to determine any differences in erosion on woodland trails. The two types of boots were conventional lug-soled boots and boots with a corrugated rubber compound sole. No significant differences between the two hiking boots were detected in comparisons of yields of organic matter and eroded soil from plots. Instead, hiking intensities produced differences in sediment yields. Trampling results in soil compaction. Differences in yields also occurred between all treated plots and untreated plots under field conditions, which were controlled for slope, soil type, canopy cover and overland runoff.


The increase in outdoor recreational activity has increased to the point that many management issues require attention. The physical carrying capacity of many parks and forests is tested by four seasons of recreational use each year. The purpose of the research is to apply the universal soil loss equation as a method for estimating the physical carrying capacity of recreational areas. The results proved that physical carrying capacity varies from place to place. The USLE does not include all the factors that have been identified as influencing physical carrying capacity. The basic guidelines provided by the USLE can be altered to suit specific needs for a given area.


This research presents of technique for managing trails using a survey method. This method efficiently characterizes the location and lineal extent of common trail problems. Trails within the Great Smokey Mountains National Park were studied because of the high use. The Trail Problem-Assessment Method (TPAM) uses a consistent search for multiple indicators of pre-defined tread problems, yielding census data documenting the location, occurrence and extent of each problem. Park managers utilized the TPAM because it provided objective and quantitative information for use in trail planning, management and maintenance decisions, and is applicable to other protected areas elsewhere with different environmental and impact characteristics.


The use of rural areas for recreational purposes continues to increase as the population increases. The deterioration and erosion of these areas requires attention so that these problems may be alleviated and dealt with in the proper manner. Natural regeneration of the habitat may take from fifty to thousands of years. This particular work suggests management strategies for managing recreational areas in order to lessen impacts as ecological problems arise. Physical carrying capacity and site selection are both mentioned as factors that require consideration when designing recreation areas.
One of the first studies to compare the effects of hikers and horses on mountain trails that are widely cited in many research projects that covers this topic. Trampling by hikers and horses cause soil compaction on level sites and initiates accelerated gully erosion on slopes. Horses will make more sediment available for transportation causing gullies on slopes. Horses were found to cause less damage on level sites when compared to hikers.

An estimated three million mountain bikers using off-road trails has lead to trails be closed to cyclist or to all users. Restricting mountain bikes to four-wheel drive roads rather than developing and estimating a random utility model that predicts the effects of trail characteristics evaluate singeltrack trails, access fees, and characteristics of the individual on trail selection. The results of the study demonstrated that bikers are willing to pay for access to preferred trails.

Another factor that can be managed is the remedial management of recreational areas that have experienced common types of damage may produce damage to the landscape. Surveying National Park Authorities in England and Wales revealed techniques to managing upland footpaths. A strategic approach, additional resources and a wider sharing of knowledge can promote proper remediation.

Conducting a long-term study was done to provide information on the impact of horse traffic on montane trails. Trails surveyed in the Rocky Mountain National Park demonstrated that intensity of use is not the controlling factor in trail stability. Geomorphic processes are a factor in soil loss and sediment production combined with climatic events. Horse use on trails promotes the exposure of the soil surface. Processes like sheetwash, rilling, gullyling and soil creep can modify the trail. Lateral and vertical erosion on trail sections is largely governed by the landforms traversed by the trail.

Studies in eight tropical or subtropical public site in Queensland, Australia were conducted to survey the impacts of recreation. In each site, plant species number, vegetation cover, plant height, and species cover frequency in untrampled, slightly trampled, moderately trampled, and heavily trampled areas were counted or measured. Soil penetration resistance and soil organic matter were recorded. Two of these eight sites showed that plant cover, height, leaf length, leaf width, and leaf thickness of each species were measured and recorded. Woody plants occurred only on untrampled areas. As wear increased the number of species and all the vegetative measurement mentioned above were reduced. When even light existed along trails trampling impacted plant height. Tall plants appeared to be more sensitive to trampling than short plants. No clear relationship between soil organic matter content and trampling intensity was found.
The alpine and subalpine environments of the Central Plateau in the Tasmanian Wilderness World Heritage Area provided the setting for research on the impacts of horse trampling and horse manure on the soils and vegetation. Soils in three different settings, shrubland, herbfield and bolster heath were analyzed. The effects of the two tested factors had a delayed effect on the three environments and little affect on dry grassland soils. Damage to vegetation was most pronounced in the shrubland. Further field experiments showed that weed establishment was limited to manure plots and was favored by the exclusion of grazing animals and ground disturbance. Trails may be necessary to limit damage in the eroded shrubland, while herbfield and bolster heath are best avoided by horseriders.


Untracked alpine vegetation in central Tasmania was used to assess the impact of walkers. Shrubs and shrublands appeared to be more vulnerable to sustained trampling damage than other lifeforms and vegetation types; damage that lasted at least twelve months occurred after between 200 and 500 passes by walkers. Damage in grassland that lasted twelve months occurred after 700 passes by hikers. Fen proved to resistant to all treatment levels immediately after trampling. Hikers produced less impact than horses on alpine grassland, fen, shrubland and bolster heath environments.


Horse riding in subalpine and alpine environments is questionable due to the amount of possible damage. Monitoring of horse riding in an area adjacent to the Tasmanian Wilderness World Heritage Area provided data from the measurement of impacts of high level horse usage on the soils and vegetation. The greatest soil loss occurred in the eucalypt forest where some 397 cm$^2$ of soil per meter width of track was lost over a two year period. Soil loss in the rainforest is less significant as the soil is churned and redistributed along the trampled and unstable track. Once tracks deteriorated into a quagmire in moorland, new tracks were established with several new braids occurring. Overall, the current level of horseriding cannot be sustained without track hardening.


Studying the relative impacts of horses, hikers, motorcycles and mountain bikes in terms of runoff and sediment yield was obtained from 108 study sites on existing trails in or near Gallatin National Forest in Montana. The use of a rain simulator provided simulation of a natural rainfall event. Each user type made one hundred passes over the sample sites. The results confirmed the complex interactions that occur between topographic, soil, and geomorphic variables noted by others, and the difficulty of interpreting their impacts on existing trails. None of the hypothesized relationships between water runoff and slope, soil texture, antecedent soil moisture, trail roughness and soil resistance was statistically significant. The incorporation of five independent variables or cross-products explained 42% of the variability in sediment yield when soil texture was added as a series of indicator variables. Ten variables combined to explain 70% of the variability in sediment yield when trail user was added as a second series of indicator variables. Using factors like soil texture (37%), slope (35%), and user treatment (35%) accounted for the largest contributions. Multiple comparisons test results showed that horses and hikers (hooves and feet) made more sediment available than wheels and that this effect was most pronounced on prewetted trails.